STS-114 Return-to-Flight Readiness

Overcoming Hurdles

Agenda

- What we do in support of the Space Shuttle
- Overcoming hurdles
- The outcome

The FDF Space Shuttle Support 1981 - 2010

- The FDF is the primary provider of STS acquisition data, which is used for antenna pointing by both the Ground and Space Networks
  - The Ground Network (GN) currently supporting the Space Shuttle is composed of 49 NASA, Air Force, and DoD tracking stations. At it's peak the FDF provided data to over 73 ground stations.
  - Space Network (SN) at White Sands - Tracking and Data Relay Satellite System (TDRSS)
- Without the support of the FDF, there is ***no*** communications with the crew or the Orbiter

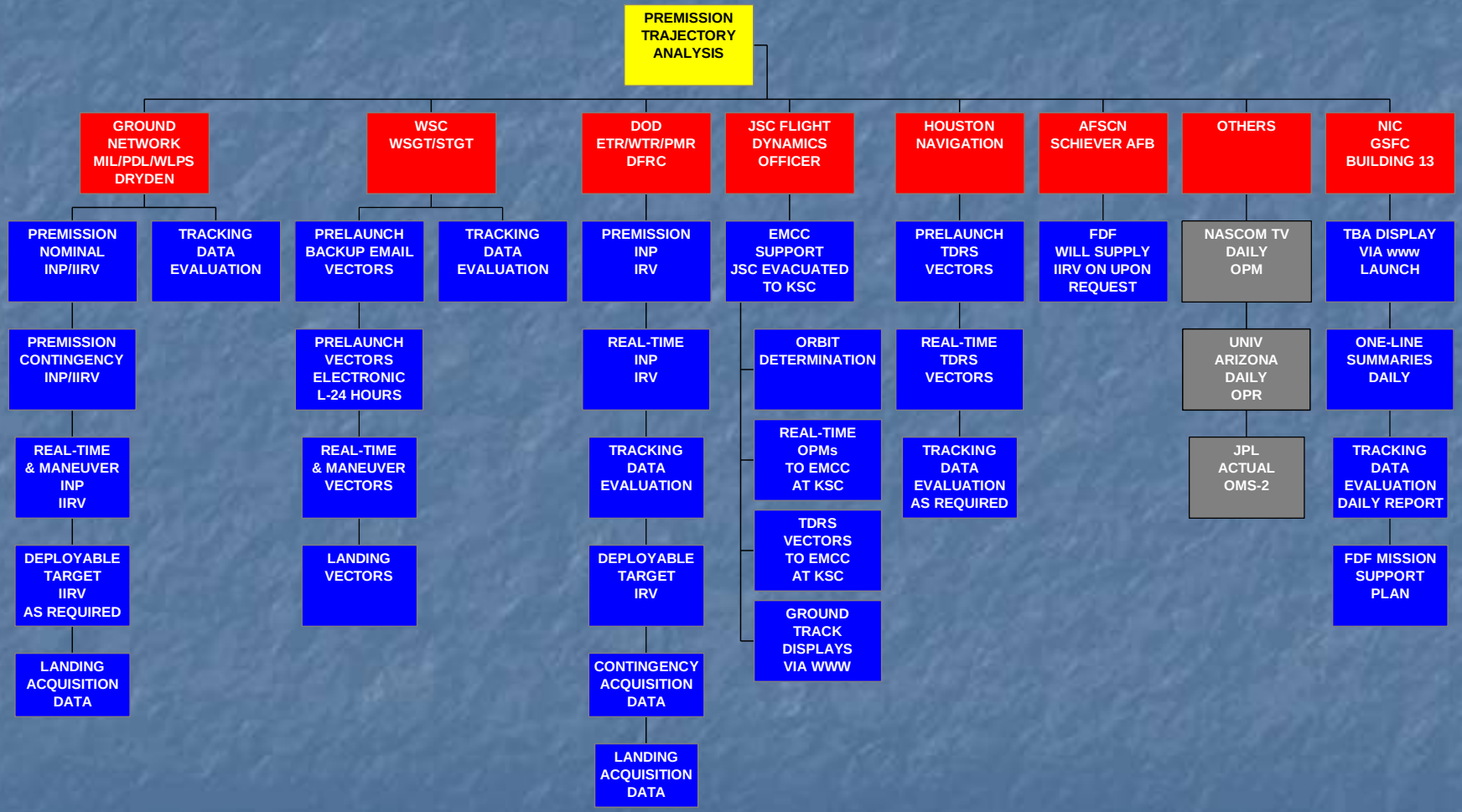
What we do

- External Interfaces/Customers
- Prelaunch Support
- Ascent Support
- On-Orbit Support
- Landing Support
- Payload Support
- Contingency Support
- STS Payload Support

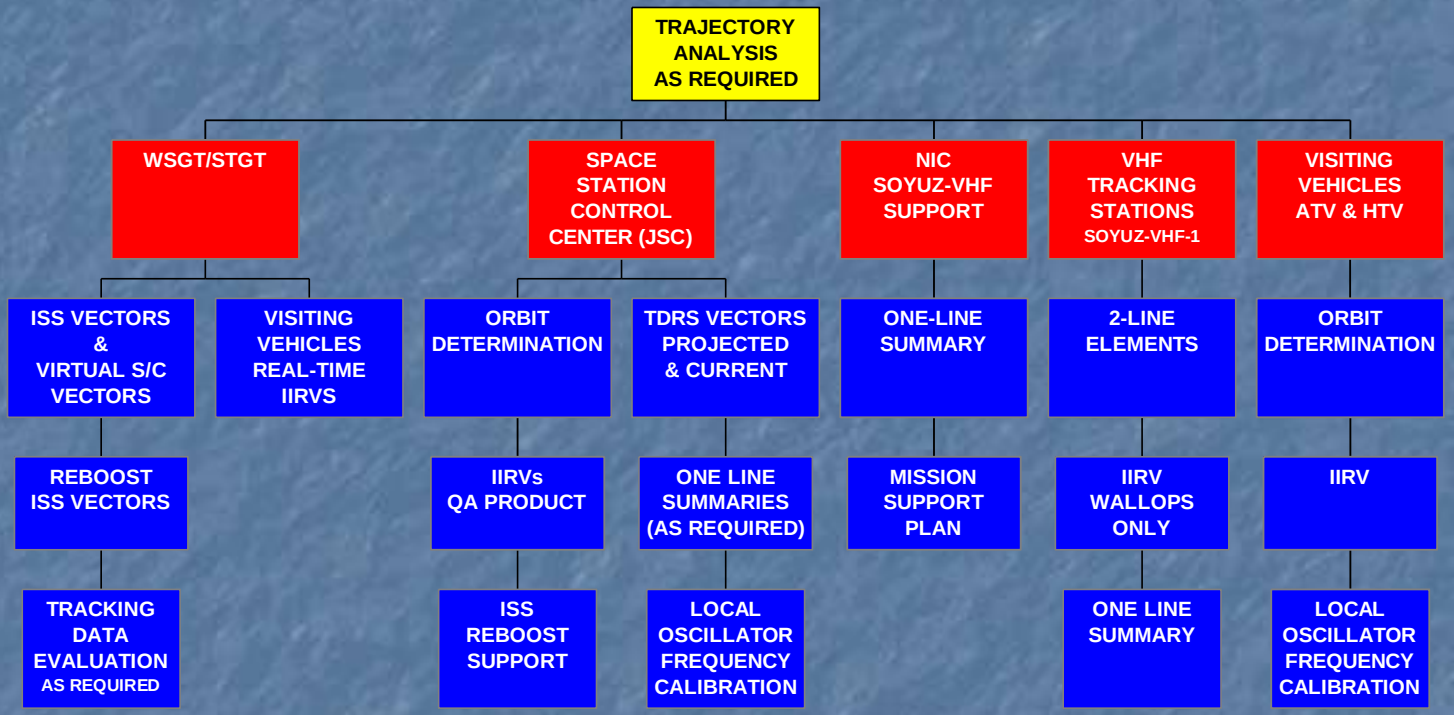
STS External Interfaces/Customers

- Johnson Space Center (JSC)
  - Data Flow Engineer (DFE)
  - Ground Navigation
  - Flight Dynamics Officer (FDO)
  - Ground Controller (GC)
- Eastern Test Range (ETR)
  - DoD Track
- White Sands Complex (WSC)
  - WSGT/STGT Operations Supervisor
  - Vector Controller
- Network Integration Center (NIC)
  - Network Director (ND)
  - STDN Mission Manager (SMM)
  - Network Operations Manager (NOM)
  - Goddard Track

STS External Customers and Products



ISS External Customers and Products



Prelaunch Support

- The FDF performs trajectory analysis to optimize SN and GN orbiter acquisition and tracking for all missions, including rendezvous missions.
  - JSC provides the FDF with premission trajectory data that model the Orbiter's ascent and early on-orbit trajectory.
  - The FDF uses these data to generate the ascent and early on-orbit acquisition data.
  - For rendezvous missions, the nominal ascent support is more complex because of the variations in the ascent trajectory across the launch window that are required for the Orbiter to match the inertial rendezvous target plane. In this case, JSC provides the FDF with several sets of premission trajectory data spaced at appropriate (inclination-dependent) intervals through the launch window, and the actual set to be used for GN acquisition data support is determined by the actual liftoff time relative to the window-open time.

Prelaunch Support

- Verify FDF and WSC SN vector processing.
- Generate and transmit nominal and contingency acquisition data for SN and GN support based on JSC- supplied trajectory data.
- Generate SN and GN scheduling products.
- Generate/Transmit TDRS vectors to JSC.
  - The FDF is the primary source of TDRS orbit determination.

Ascent Support

- Generate and transmit launch (including MECO and OMS-2) acquisition data to the SN and GN.
- Provide TDRSS analytical support to verify correct TDRS antenna pointing and vector processing using trajectory related displays.
- Evaluate metric tracking data.

On-Orbit Support

- Generate and transmit STS hourly nominal and maneuver acquisition data to the SN and GN based on JSC vectors.
- Transmit hourly acquisition data for deployable and/or rendezvous spacecraft when required.
- Generate SN and GN planning products every 24 hours based on JSC 48-hour planning vectors.
- Evaluate SN and GN metric tracking data.
- Generate/Transmit TDRS vectors to JSC, including pre- and post-maneuver vectors.

Landing Support

- Receive predicted nominal and 1 rev late landing maneuver sets from JSC.
- Based on these landing sets, generate and transmit acquisition data for the SN and GN.
- Generate and transmit backup support vectors to WSC.
- Confirm correct TDRS antenna pointing and WSC vector processing.

Payload Support

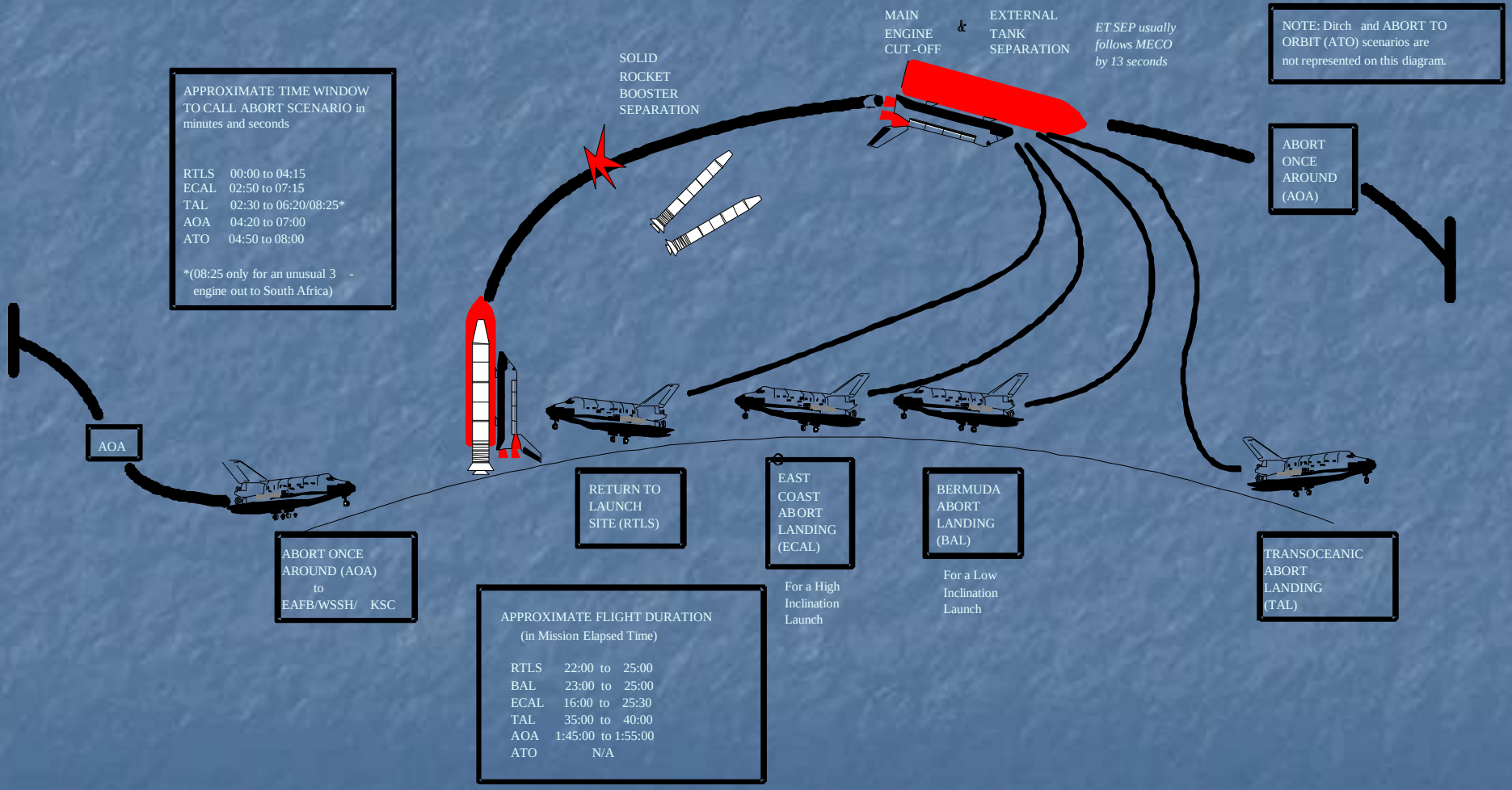
- The FDF has also supported many of the significant Space Shuttle payloads:
  - TDRS-1 – 7
  - HST (and subsequent servicing missions)
  - ERBS
  - GRO
  - UARS

Nominal Flight

Contingency Support

- Shuttle Vehicle Contingencies
  - Return to Launch Site (RTLS)
  - East Coast Abort Landing (ECAL)
  - Transoceanic Abort Landing (TAL)
  - Ditch Landing
  - Abort to Orbit (ATO)
  - Abort Once Around (AOA)
  - Emergency Landing
- JSC Facility Contingencies
  - Shuttle
  - ISS

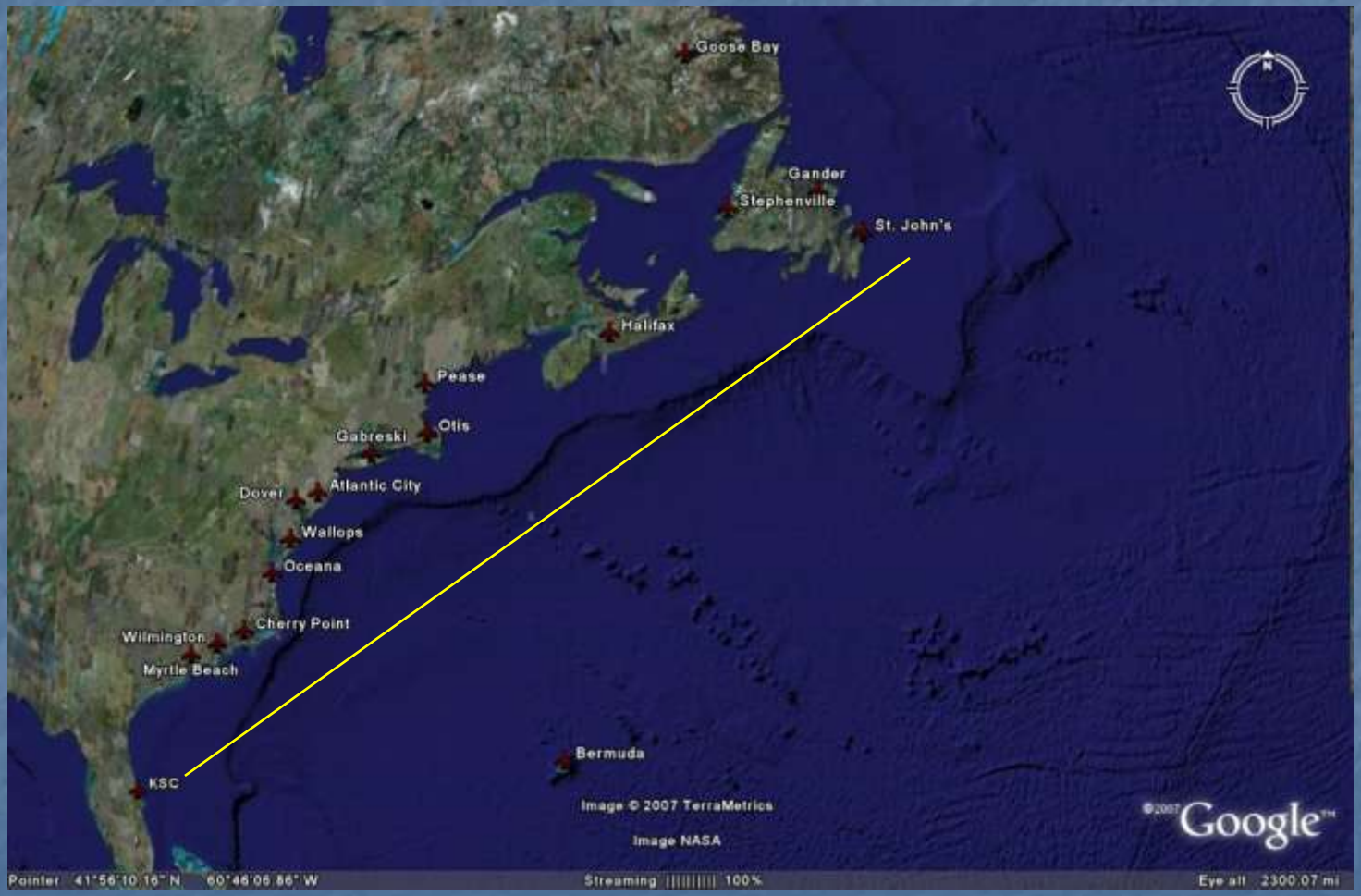
Space Shuttle Aborts



STS Launch Abort Scenarios

- **Return To Launch Site (RTLS)**
  - Early shutdown of one or more engines and without enough energy to reach a TAL site would result in the Orbiter pitching around and thrusting back toward KSC until within gliding distance of the SLF.
- **East Coast Abort Landing (ECAL)**
  - This is the abort scenario that falls between RTLS and TAL. The Orbiter would attempt to land at one of the following runways:
    - Horry County Jetport, South Carolina
    - Cherry Point Marine Corps Air Station MCAS, North Carolina
    - Wilmington, North Carolina
    - Oceana Naval Air Station NAS, Virginia
    - Wallops Flight Facility, Virginia
    - Dover Air Force Base AFB, Delaware
    - Atlantic City International Airport, New Jersey
    - Francis S. Gabreski Airport, Long Island, New York
    - Otis Air National Guard Base ANGB, Massachusetts
    - Pease ANGB, New Hampshire
    - Halifax International, Nova Scotia, Canada
    - Stephenville, Newfoundland, Canada
    - St. Johns International, Newfoundland, Canada
    - Gander International, Newfoundland, Canada
    - Goose Bay, Newfoundland, Canada

East Coast Abort Landing Sites



STS Launch Abort Scenarios

- **Transoceanic Abort Landing (TAL)**
  - Loss of one or more main engines midway through powered flight would force the Orbiter to land at Le Tube, France; Moron, Spain; or Zaragoza, Spain. The TAL landing sites are based on launch inclination. For flights to the ISS the primary TAL site is Zaragoza, and the alternate sites are Moron and Le Tube.
- **Ditch**
  - The Orbiter would be unable to make landfall and would ditch into the water.

STS Launch Abort Scenarios

- **Abort To Orbit (ATO)**
  - Partial loss of main engine thrust occurs late enough to permit reaching a minimal 105-nautical-mile orbit with OMS engines.
- **Abort Once Around (AOA)**
  - Early main engine shutdown with the capability to allow one orbit around before landing at Edwards Air Force Base (EAFB), CA; White Sands Space Harbor (WSSH), NM; or the Shuttle Landing Facility (SLF) at Kennedy Space Center, FL. The landing site is dependent on launch inclination. For flights to the ISS , the prime AOA landing site is at the KSC and the alternate landing site is WSSH.
- **Emergency Landing Sites (ELS)**
  - In the event that an in-flight emergency is declared, an attempt will be made to perform an landing at one of the approximately 64 ELS runways through out the world.

Actual Contingency Support During STS-75 - February 25, 1996

- The Tethered Satellite System (TSS) flying on STS-75 was marred by loss of the satellite on flight day three when the tether broke. Valuable scientific data was still able to be gathered.
  - Although the FDF was not scheduled to support the TSS, once the tether broke we anticipated that we would be called upon to provide acquisition data. So before being requested to provide support, the FDF systems were configured and ready to support the satellite.

Contingency Support - EMCC

- Emergency Mission Control Center (EMCC) support in the event JSC has to be evacuated to KSC.
  - FDF becomes prime for STS orbit determination.
  - SN and GN acquisition data based on FDF solutions for on-orbit support.
  - Vectors computed by the FDF are used by the EMCC to determine the STS deorbit burn time.
  - Provide SN vectors for landing support
  - Provide GN acquisition data for landing support
- The FDF and JSC routinely simulate in this function to maintain proficiency.
- A the start of the STS program the EMCC was located at GSFC in Building 3, Room 60A.

The Hurdles

- Contract change
- Loss of experienced personnel
- Loss of proficiency due to inactivity
- Getting ready for STS-114

Contract Change
January 1, 2004

- End of the Consolidated Space Operations Contract (CSOC)
- New Mission Operations and Mission Services (MOMS) contract called for more customer oversight.

Loss of Experienced Personnel Due to Contract Change

- Staffing prior to the contract change:
  - The FDF provided 24/7 console support for all phases of the mission.
  - There were 11 certified persons available to provide console support.
  - Except for launch and landing, the high level of experience allowed staffing to be 1 person per shift.
- Staffing after the contract change:
  - The FDF was still required to provide 24/7 console support for all phases of the mission.
  - Only 4 certified persons remained to provide console support .
  - Eight new hires needed training before return-to-flight.

Personnel Training and Certification

- During this period of almost 2½ years without an STS flight, members of the FDF core STS team strove to maintain their proficiency and took the opportunity to train new team members.
- The FDF had several individuals who have worked every STS mission since 1998. These individuals were qualified to work the on-orbit phase of the mission, but were provided refresher training six weeks prior to launch. The FDF had an established launch and landing team already in place.
- A certification plan was developed and implemented for the positions that were to play a critical role in supporting STS-114. The certification plan became the basis for STS training in the FDF.

Personnel Training and Certification

- In addition to the certification plan, a training plan was developed that included classroom instruction and simulation support using the actual hardware and software used for STS missions.

Personnel Training and Certification

Classroom Topics

- WSC vectors and coordinate system
- WSC vector propagation
- TBA results discussion
- Voice circuit configuration and procedures
- STS requirements overview
- WSC vector processing
- GN and SN overview
- Launch contingencies
- Facility contingencies
- Rendezvous mission support
- Overview of JSC support elements
- EMCC procedures
- FDF internal elements overview
- Premission procedures
- Products and customers
- Console activities
- Development of ECAL support vectors
- D-Tape and generic trajectories

Personnel Training and Certification

Real-time Mission Software and Hardware Topics

- STS Hourly Vector Processing - ADG* (w/voice procedures)
- STS Network Launch Simulation ADG (w/voice procedures)
- STS Network Launch Simulation - Tracking Data Evaluation
- SN Proficiency Simulation - ADG
- SN Proficiency Simulation – TBA*

* FDF Institutional Software

Off-line Mission Software and Hardware Topics

- Premission acquisition data generation and transmission
- Premission product generation
- Configuration and use of electronic logging

What else

- At the request of the customer, the FDF supported the GSFC PAO effort leading up to and during the STS-114 mission. Supporting personnel were interviewed by GSFC PAO personnel as well as by the local TV and newspaper media. This effort provided a positive image of the FDF and its importance to the STS program.

- The FDF provided ISS Backup Control Center (BCC) contingency support during the closure of the Johnson Space Center (JSC) because of Hurricane Rita. The FDF delivered ISS BCC products, composed of ISS and TDRS vectors, to the FDF Product Center for use by the JSC ISS flight controllers who had relocated to GSFC prior to the arrival of the hurricane.

The Outcome

- As a result of premission training and actual STS-114 support, nine individuals were able to actively make a contribution to the mission and become the foundation of future FDF Space Shuttle support.
- One individual received the Space Flight Awareness (SFA) award for outstanding support during STS-126. This award is one of the highest presented to NASA and industry. It is presented to employees for their dedication to quality work and flight safety.
- Many of the newly trained individuals who supported STS-114 were awarded a Team Spaceflight Awareness Award. This award is used to recognize small groups of employees that have demonstrated exemplary teamwork while accomplishing a particular task or goal in support of the human space program.

Team Spaceflight Awareness Award

Flight Dynamics Facility

FDF Real Time Support

Questions - Comments

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Acronyms

- ADG Acquisition Data Generator
- AFSCN Air Force Satellite Control Network
- AOA abort once around
- ATO abort to orbit
- DoD Department of Defense
- ECAL East Coast abort landing
- EMCC Emergency Mission Control Center
- ER Eastern Range
- ERBS Earth Radiation Budget Satellite
- EUVE Extreme Ultra-Violet Explorer
- FDF Flight Dynamics Facility
- FDO Flight Dynamics Officer
- GN Ground Network
- GTDS Goddard Trajectory Determination System
- HST Hubble Space Telescope
- JSC Johnson Space Center
- KSC Kennedy Space Center
- MECO main engine cutoff
- MIL Merritt Island
- MTDE Metric Tracking Data Evaluation
- ND Network Director
- NIC Network Integration Center
- NOM Network Operations Manager
- OD orbit determination
- OMS Orbital Maneuvering System
- PAO Public Affairs Office
- PMR Pacific Missile Range
- RTLS return to launch site
- SLF Shuttle Landing Facility
- SMM STDN Mission Manager
- SN Space Network
- STDN Spaceflight Tracking and Data Network
- STGT Second TDRSS Ground Terminal
- STS Space Transportation System
- TAL transoceanic abort landing
- TBA TDRS Beam Angle
- TDRS Tracking and Data Relay Satellite
- TDRSS Tracking and Data Relay Satellite System
- UARS Upper Atmosphere Research Satellite
- WSC White Sands Complex
- WSGT White Sands Ground Terminal
- WR Western Range